Innovative system removes "soot" from diesel exhaust

O A A T A C C O M P L I S H M E N T S

Microwave-Regenerated Diesel Engine Exhaust Filters

Challenge

High-efficiency, advanced diesel engine technology is a leading near-term option for reducing oil imports and petroleum consumption in the United States. However, diesel engines face serious challenges in meeting the EPA 2004 Tier 2 vehicle emissions standards for oxides of nitrogen (NO_x) and particulate matter (PM). The solution requires developing new emission control systems and advanced fuels. For light-duty vehicles, new emission control systems must reduce engine-out emissions of NO_x and PM by approximately 90%, while minimizing adverse effects on fuel economy.

For PM reduction, current diesel engine particulate filter technologies depend on a catalyst to assist in regenerating the filter (returning it to a "like new" condition). Catalysts typically require an exhaust temperature of approximately 350° C to be effective, usually requiring adjustments to engine operating conditions and/or using fuel additives. U.S. Department of Energy (DOE)-supported research faced the challenge of finding a more effective means of maintaining adequate exhaust temperatures that would not be as dependent on engine temperature.

Technology Description

DOE researchers developed a special silicon-carbide fiber technology that can be formed to trap PM and also efficiently convert microwave energy to heat energy for regeneration. A small mass of these fibers can quickly achieve high temperatures for PM trap regeneration, even during cold starts or while idling.

Silicon-carbide fibers incorporated into an exhaust filter cartridge.

The silicon-carbide fibers are incorporated into a filter cartridge and microwave regeneration system, sized for use in diesel engine exhaust streams. The cartridge is encased in a tuned, ceramic microwave cavity connected to a microwave power source.

Accomplishments

The microwave filter system was tested in a laboratory setting on three diesel engines: the Ford 1.2-liter DIATA, the Navistar 7.3-liter, and the Volkswagen 1.9-liter. Compared to the target of 75% PM removal efficiency, the three engine tests demonstrated 80-95% removal efficiency. Also, compared to the target of 90% regeneration efficiency, the three engine tests demonstrated 95-100% regeneration efficiency.

Under simulated driving conditions, the microwave filter system requires regeneration about every six hours. Regeneration consumes 1.75 kW of power over a two-minute period. The microwave power requirement translates into 2.7 kW of engine electrical power, which imposes only a 0.3% penalty on fuel economy.

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Benefits

The microwave-regenerated filter system will permit vehicles to meet EPA 2007 Tier 2 standards for diesel engine PM emissions. Since the microwave system operates independently of engine conditions, it can reduce particulates to acceptable levels and regenerate the filter even during cold-starting and idling. This feature may help offer a solution to cold-start hydrocarbon (HC) and carbon monoxide (CO) emissions from diesel – and also gasoline – engines, which the EPA recently placed under greater scrutiny.

Microwave-regeneration eliminates adjusting engine operating conditions and/or using fuel additives to achieve effective catalyst regeneration temperatures.

The system helps reduce the impact on fuel economy to about 0.3%, or more than 90% less than with other types of filter regeneration systems.

Future Activities

The system will be installed on vehicles for on-road durability testing. To demonstrate its commercial potential, the microwave-regenerated filter system will be developed for selected car and engine types.

Partners in Success

- Industrial Ceramic Solutions, LLC
- Microwave Materials Technologies, Inc.
- Oak Ridge National Laboratory